

Section 3 Regulatory Time Frame¹

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Issue A: EPA should establish the compliance period at an appropriate time beyond 10,000 years. For a variety of reasons, the proposed compliance period of 10,000 years is too short.

1. Numerous models have shown that the peak dose will occur well after the proposed 10,000 year compliance period. The proposed 10,000 year compliance period is arbitrary and should be extended to at least the time of peak dose. (4, 23, 94, 138, 173, 180, 206, 281, 334, 353, 369, 384, 425, 438, 457, 471, 482, 500)
2. Numerous alternative specific compliance periods beyond 10,000 years were suggested to ensure that peak doses are covered, including 50,000, 100,000, 200,000, 300,000, 500,000, and one million years. A few suggested that the standard should apply for all time. (23, 177, 184, 186, 196, 353, 409, 452, 482, 759)
3. The compliance period for the standard should be comparable to the hazardous lifetime of the materials to be emplaced in the Yucca Mountain repository. The repository will contain significant amounts of radioactivity for hundreds of thousands to millions of years. (52, 119, 167, 191, 206, 341, 353)
4. The predicted radioactive content in Yucca Mountain after 10,000 years of radioactive decay will [be] greater than the total amount of radioactivity placed in WIPP before any radioactive decay happens. Thus if WIPP is to be used to justify a time limit for compliance at Yucca Mountain, the compliance time should be (defined in total Ci) as that necessary for the waste [at] Yucca Mountain to decay to the same level WIPP will reach at 10,000 years. Then and only then, will it be possible to claim that YM will be as safe as WIPP. (220)
5. DOE has projected that peak doses will occur at 100,000 years and after, and would be orders of magnitude higher than EPA's proposed standard. (186)

¹ All acronyms are defined in Appendix B.

6. Given that the peak dose may occur beyond 10,000 years and exceed the proposed dose limits, future generations should not be subjected to unacceptable levels of radiation. They deserve the same level of protection as that provided in the proposed 10,000 year standard. (128, 143, 409, 425, 429, 457)
7. A 10,000 year compliance period may be pragmatic but with peak risk (or dose) occurring after 10,000 years, the licensing process may become more difficult. (466)
8. The NAS Panel recommended that adequacy of health protection be assessed for the time of greatest calculated dose, rather than by applying arbitrary cutoffs at earlier times, as this proposal would do. (398)
9. The quantity of long-lived radionuclides is far greater and the specific mix of radionuclides at Yucca Mountain is different from that in the WIPP, where 40 CFR 191 is the governing rule...EPA has not provided sufficient grounds to reject the NAS report's conclusion that estimates could be made for up to one million years. Its rejection of the NAS report's recommendation regarding compliance at the time of peak dose is scientifically and environmentally inappropriate. (281)
10. The EPA suggests that rather than setting the regulatory period to extend to the time of peak dose, DOE should consider this matter of extraordinary peak dose rates in its EIS. This evasion of regulatory responsibility is unacceptable despite the EPA's argument that beyond 10,000 years uncertainties in performance assessments become overwhelming. (127)
11. With regard to the EPA's choice of a 10,000 year compliance period, this was apparently based, in part, on the assumption that generic sites could be chosen that would assure long groundwater travel times, that is, for at least the thousand years that it would take for the water to migrate. (153)
12. In response to the regulatory dilemma posed in the commentary for the Proposed Rule, if the projected peak dose, at whatever time it might occur, is accompanied by an uncertainty range of 5 orders of magnitude around the standard, there should be no compliance dilemma at all. The repository license application should be rejected. (385)
13. The period of compliance must be greater than only 10,000 years...The way to prevent DOE falling into the optimism trap or even hiding the truth during licensing, is to set a standard that gradually relaxes the dose for compliance as time increases. (412)

Response To Issue A.1 through A.11:

EPA is aware that numerous estimates project that doses from the proposed Yucca Mountain repository may reach their peak sometime after the proposed 10,000 year compliance period. Further, the 1995 NAS report on Yucca Mountain (“Technical Bases for Yucca Mountain Standards,” August 1, 1995, National Academy Press, Washington, D.C., or, more simply, “the NAS Report”) recommended that the compliance period should be “the time when the greatest risk occurs, within the limits imposed by long-term stability of the geologic environment.” (NAS Report, p. 7). This period of long-term geologic stability could extend to one million years, according to the NAS Report (p. 6). The NAS based its recommendation upon technical, not policy considerations. Specifically in regard to the time period when the standard should apply, the NAS noted “...although the selection of a time period of applicability has scientific elements, it also has policy aspects that we have not addressed” (NAS Report, p. 56). As discussed below, the NAS Report explicitly recognized that policy considerations might also factor into the determination of the appropriate compliance period. EPA has carefully considered this issue and we conclude that the selection of the compliance period involves both technical and policy considerations. EPA’s goal is to establish health and safety standards that protect the public from releases of radioactive materials from Yucca Mountain. An important consideration in this regard is whether the standard is practical to implement. Furthermore, DOE’s calculation of peak dose after the period of compliance as a part of the environmental impact review process allows for public comment to contribute constructive suggestions that may impact how the repository is ultimately designed, operated, and closed. For a variety of reasons, we believe that a 10,000 year compliance period, along with the requirement for the EIS to include a calculation of peak dose beyond 10,000 years but within the period of geologic stability, is meaningful, protective, and practical to implement and, further, will encourage a robust repository that will provide long term protection of the public health and the environment.

First, while the NAS suggested a compliance period that would extend to the time of peak risk, within the period of geologic stability for Yucca Mountain (which might be up to one million years), the panel also recognized that such a decision has policy aspects not addressed by the NAS (NAS Report, p. 56). It suggested, for example, that “EPA might choose to establish consistent policies for managing risks from disposal of both long-lived hazardous nonradioactive materials and radioactive materials.” With respect to the compliance period, EPA has used a 10,000 year limit in programs related to hazardous wastes. Waste subject to the land disposal restrictions requirements of the RCRA must meet a variety of requirements before land disposal is authorized (see 40 CFR part 268). Facilities may seek an exemption from these requirements by demonstrating that there will be no migration of hazardous constituents from the disposal unit for as long as the waste remains hazardous (40 CFR 268.6). With respect to the WIPP no-migration petition, 10,000 years was judged the longest practical timeframe for evaluating this petition (55 FR 13068, 13073, April 6, 1990). With respect to underground injection wells under the purview of the SDWA, we have specifically required a demonstration that the injected fluid will not

migrate within 10,000 years [40 CFR 148.20(a)]. More recently, modeling conducted in support of our HWIR has been carried out for 10,000 years to assess human health and ecological impacts (64 *FR* 63381, November 19, 1999). It is apparent that a compliance period of 10,000 years is the longest timeframe that has proved practical in our regulation of a variety of hazardous wastes.

Second, EPA has concerns related to uncertainty in projecting human exposure over extremely long time periods (up to a million years), such as those advocated by the NAS report and the commenters. One commenter (281) states that we have not provided sufficient reason not to adopt the NAS recommendation to evaluate peak dose for the period of geologic stability, and that our stated reasoning is inconsistent and not sound. We disagree with this commenter. Over such long time periods, we do agree that it is possible to calculate the performance of the Yucca Mountain disposal system within certain bounds. Indeed, numerous commenters (128, 186, 143, 409, 425, 429, 457, 466) expressed concern that the peak dose beyond 10,000 years may exceed the dose limits in the final standards. Such a calculation, however, entails two aspects of uncertainty that may call into question the meaning of any projections of human health impact over such times and consequently the value of such projections in a licensing process. One aspect of uncertainty relates to the **impact of long-term natural changes**. For extremely long time periods, major changes in the global climate could occur (see, for example, Chapter 7, BID). While the climate likely will remain, in general, similar to present day conditions over the next 10,000 years, over longer time frames comparable to the NAS suggested time of geologic stability, geologic evidence suggests that the global climate regime will likely pass through several glacial-interglacial cycles, with the majority of time spent in the glacial state (NAS Report, p. 91). These longer time periods would require the specification of exposure scenarios that would not be based upon current knowledge but rather upon potentially arbitrary assumptions. The NAS indicated that it knew of no scientific basis for identifying such scenarios (NAS Report, p. 96). As noted by the IAEA, beyond 10,000 years it may be possible to make general predictions about geological conditions but the range of possible biospheric conditions and human behavior is too wide to allow “reliable modeling” (IAEA TECDOC-767, 1994, p. 19, Docket A-95-12, Item II-A-5).

The second aspect of uncertainty associated with extremely long time periods relates to the **possible biosphere conditions and human behavior**. Even for periods as “short” as 10,000 years, it is necessary to make certain assumptions. This time period is twice as long as recorded human history and represents a very long compliance period for current-day assessments. For periods on the order of one million years, even natural human evolutionary changes become a consideration, disregarding the recent advances in genetic engineering. Thus, reliable modeling of human exposure may be untenable and regulation to the time to peak dose, as suggested by the NAS Report and at least one commenter (281), is likely to become arbitrary.

Third, EPA considered this issue and comprehensively evaluated the appropriate regulatory compliance period promulgated in the generally applicable environmental standards for the land disposal of SNF, HLW, and TRU wastes at 40 CFR part 191. The individual-protection requirements and ground-water protection standards (58 *FR* 66398, 66414, 66415, December 20, 1993), as well as the containment requirements (50 *FR* 38086, September 19, 1985), in 40 CFR part 191 require a compliance period of 10,000 years. One comment (153) suggested that this compliance period was based on the assumption that generic sites would be chosen that would exhibit long ground water travel times. Rather, the 10,000-year compliance period in 40 CFR part 191 was chosen for a variety of reasons, without relying on specific assumptions about ground water travel times. It allows well-designed, well-sited repositories to be distinguished from poorly sited and/or poorly engineered repositories. At the same time, major geologic changes are unlikely and repository performance can be reasonably projected over a 10,000-year period. (50 *FR* 38070-38071, September 19, 1985) EPA is also implementing a 10,000 year regulatory time period in the application of 40 CFR part 191 to the WIPP TRU waste repository in New Mexico (63 *FR* 27354, May 18, 1998). Notably, these 40 CFR part 191 standards apply to the same types of waste and type of disposal system (deep geologic repository) as proposed for Yucca Mountain. The WIPP LWA (Public Law No. 102-579, as amended by Public Law No. 104-201), however, exempted Yucca Mountain from the 40 CFR part 191 standards and Congress established a separate standards setting process detailed in the EnPA (Public Law 102-498), the authority for this rulemaking. Adopting a 10,000 year compliance period for Yucca Mountain would provide a consistent regulatory period for the land disposal of all SNF, HLW, and TRU waste in this country.

On this point, one commenter (220) argues that EPA is inappropriately using its WIPP experience to justify a 10,000 year compliance period for the Yucca Mountain repository. The commenter correctly points out that the radioactivity of the waste at Yucca Mountain will far exceed the expected inventory at the WIPP, and suggests that the appropriate compliance period for Yucca Mountain would be the time that it takes for radioactivity at the repository to decay to the same levels expected at the WIPP after 10,000 years. We disagree with this position, and believe that the commenter has too narrowly focused on the application of the 40 CFR part 191 standards to a single facility, the WIPP. Part 191 also applies to SNF and HLW, and would have applied to the Yucca Mountain repository had Congress not directed EPA to set site-specific Yucca Mountain standards.

At the time 40 CFR part 191 was developed, the bulk of the technical analyses supporting the rulemaking were aimed at evaluating SNF disposal (see EPA's 1985 BID, EPA 520/1-85-023, Docket R-82-3). Nevertheless, the limits of 40 CFR part 191 apply to the land disposal of radionuclides whether they originate from any combination of SNF, HLW, or TRU waste. EPA focused on SNF because of the excellent quality and amount of information available regarding the characteristics and volume projections for spent fuel. SNF also represented the highest inventory of wastes to be disposed and included many of the same radionuclides found in both

HLW and TRU waste. By contrast, DOE had characterized HLW and TRU waste but this data contained considerable variability and uncertainty. As pointed out by commenters (220, 281), the inventory of radionuclides in SNF proposed for Yucca Mountain is much greater, and the radionuclide composition is different, than that in the TRU waste destined for WIPP. That being the case, there is no simple correlation between inventory and the risk to the public. The dose to an offsite individual or group is ultimately determined by a whole host of factors. In addition to inventory, the isolation capabilities of the natural geology, the engineered barriers included in the repository design, and site hydrogeology and climatology, among other factors, all may strongly affect the ability of the repository to isolate radioactive wastes for extended periods. These factors will be part of the full record presented to NRC as it makes its licensing decision. It will be important to evaluate projections of repository performance in light of the greater uncertainties associated with such long-term assessments, while not excluding important parameters from assessments simply because they are difficult to quantify.

Fourth, numerous international repository programs already invoke a 10,000 year compliance period. Canada, France, Germany, and Sweden have established 10,000 year compliance periods but have also committed to perform some kind of evaluation of the disposal system for time periods beyond 10,000 years [see NAS Report, Table 2-3, at 43, and GAO/RCED-94-172, “Nuclear Waste, Foreign Countries’ Approaches to High Level Waste Storage and Disposal,” August 1994 (Docket A-95-12, Item V-A-7)].

Fifth, a compliance period beyond 10,000 years would be unprecedented. Neither any of our national disposal programs nor international programs have implemented a compliance period approaching that suggested by the NAS panel (times approaching one million years). Given the unmanageable uncertainties associated with extremely long compliance periods on the order of one million years, a more complicated licensing process would undoubtedly result with no additional discernible benefits. Focusing upon a 10,000-year compliance period forces more emphasis on those factors over which our present society can exert some degree of control, such as repository design features and engineered barriers. By focusing upon an analysis of the features that society can influence or dictate at the site, it becomes more likely that the magnitude of the peak dose can be minimized even for periods beyond 10,000 years.

In a similar vein, another commenter (184) raised DOE’s modeling capability as justification for EPA to set an unlimited compliance period. The commenter states that if DOE cannot demonstrate compliance with the standard in the short term (10,000 years), that will indicate either that the site is unsuitable or that knowledge is insufficient to site the repository. If DOE cannot demonstrate compliance with the standard over much longer periods, it shows that DOE has “a total lack of real understanding” of the processes at work in the repository and a “lack of justifiable predictive capability”. It is noted that if DOE is unable to demonstrate compliance within the 10,000-year compliance period in the final rule, NRC would be unable to approve a license for Yucca Mountain. Over longer time periods, our rule requires calculation of peak dose

but we realize the modeling supporting quantitative assessments becomes much more tenuous, as discussed previously. If the post-10,000 year modeling results exceed the limits in our standard, the commenter argues, the repository also should not be sited at Yucca Mountain. In fact, one commenter (127) accused EPA of evading its regulatory responsibility for not requiring compliance until the time of peak dose. We strongly disagree that we have evaded our regulatory responsibility. We have established a protective final standard that applies for 10,000 years, the longest practical, meaningful, implementable time period achievable, and in light of some of the unmanageable uncertainties discussed above, we still require a calculation of peak dose beyond the 10,000-year compliance period. We believe this approach achieves a proper balance between meaningful assessments over a hard 10,000-year compliance period and less reliable assessments clouded by the considerable and different uncertainties that emerge beyond 10,000 years. We do believe, however, that a post-10,000 year assessment would make more complete information available and offer opportunities to enhance long-term (>10,000 years) performance. We refer to our above discussion of uncertainty considerations, particularly those associated with long-term (>10,000 years) projections. Uncertainty is but one of the many factors that will enter into a compliance determination by the NRC.

For the reasons cited above, EPA believes that a 10,000-year compliance period is meaningful, practical to implement, and will result in a robust repository protective for time periods beyond 10,000 years. Imposing a 10,000-year compliance period on Yucca Mountain means that the health and safety standards promulgated in this rule to protect the public from releases of radioactive materials from Yucca Mountain will have force and effect for 10,000 years. Moreover, imposing a compliance period beyond 10,000 years would introduce significant and unmanageable uncertainties in the licensing process, and would likely complicate the licensing process so as to dilute the meaning of any associated licensing determinations. Also, a compliance period beyond 10,000 years would be unprecedented both nationally and internationally. A 10,000-year compliance period for Yucca Mountain, in conjunction with the requirements of our generally applicable standard (40 CFR part 191), ensures that all SNF, HLW, and TRU wastes disposed anywhere in the United States will be held accountable to a 10,000-year compliance period. A 10,000-year compliance period also is the longest timeframe that has proved practical in our regulation of a variety of hazardous wastes. At the same time, consideration of the impacts beyond 10,000 years as a part of the environmental impact review process allows the public and decision makers to consider alternatives for enhancing long-term repository performance. We believe this is the appropriate balance that allows for meaningful consideration of the issues related to both “short” term (up to 10,000 years) and “long” term (10,000 years to one million years) aspects of repository development.

Response to Comment A.12:

Regarding uncertainty within the regulatory period, it was suggested that the license application should be denied if modeling results showed an uncertainty range of five orders of magnitude around EPA’s dose standard. What is required, however, is a “reasonable expectation” that the standard will be met. As indicated in our proposal, calculation of doses to the RMEI involves projecting doses that are within a reasonably expected range rather than projecting the most

extreme case. This is in concert with the NAS recommendation to use “cautious, but reasonable” assumptions in defining who is to be protected (NAS Report, pp. 5, 6). Modeling results, and their associated uncertainties, are but a part of the full record upon which NRC will determine compliance with this rule.

Response to Comment A.13:

This commenter suggested that it would be possible to prevent overly optimistic projections for very long time periods by gradually relaxing the standard as time progresses. This would allow DOE to demonstrate “graceful degradation” of the repository system and avoid “big surprises” created by errors in the performance assessment. Under this scenario, the standard would increase to 150 mrem from 10,000-100,000 years, and to 1.5 rem from 100,000-1,000,000 years. Curiously, the commenter offers this approach as a way to counter DOE’s “horrendous track record in protecting health and safety”, which shows the “political and technical credibility and competence of the DOE”. EPA finds this proposal to be flawed for several reasons. First, no regulatory body that we are aware of considers doses of 150 mrem to be acceptable, much less 1.5 rem, for members of the general public. Such exposures may be experienced by radiation workers but they are not members of the public (see 10 CFR 20.1201, for example). Second, while our standard requires compliance for 10,000 years, we also require that DOE project performance beyond 10,000 years and place these projections in its final EIS. We do not require that NRC use those projections to determine compliance with our standard, nor do we preclude NRC from doing so if it believes that they provide insight into the long-term performance of the disposal system (e.g., the “big surprises” envisioned by the commenter). In any case, projections beyond 10,000 years will provide a more complete evaluation of disposal system performance. Third, we do not see why a relaxed standard such as that proposed by the commenter would provide any additional confidence in DOE’s ability to assess performance for the first 10,000 years. Finally, the uncertainties involved in very long-term assessments would make it more difficult to judge compliance with any numerical standard, as discussed in the response to Issues A.1 through A.11 above. For a period of 10,000 years, it may be more effective to focus on features over which repository designers can exercise some control, which should positively influence disposal system performance beyond 10,000 years.

Issue B: The proposed 10,000 year compliance period, coupled with DOE’s calculation of peak dose after 10,000 years in the Yucca Mountain environmental impact statement, is appropriate/reasonable.

1. A 10,000 year compliance period is reasonable. Just because it is feasible to calculate the performance of engineered and geologic barriers, as well as radiation doses to human beings, beyond 10,000 years does not imply that such results will be meaningful or realistic. (79, 228, 234, 271, 327, 476, 514, 551, 557, 566, 615)
2. Given the greater uncertainties associated with projections of repository performance beyond 10,000 years, there is no guarantee of greater public health benefit for projections beyond 10,000 years. (228, 526)

3. Requiring a compliance period beyond 10,000 years would unnecessarily complicate the licensing process because of the extreme uncertainty accompanying any such dose calculations. (216, 265, 776)
4. Requiring a compliance period longer than 10,000 years would be unprecedented. (216)
5. Given that there will likely be impacts beyond 10,000 years, DOE should calculate the peak dose, within the period of geologic stability, and display these doses in the Yucca Mountain EIS so that the public and all decision makers are fully informed. (80, 234, 303, 327, 779)
6. Given that the proposed EPA standard requires that the performance of the disposal system be examined after 10,000 years if the peak dose is calculated to occur then, there may be little practical difference between the TYMS report's recommendations and the proposed EPA standards. The major issue is that EPA provides no guidance on how analyses should be done for the period of geologic stability beyond 10,000 years and gives no indication of how the results should be use in judging acceptability. (398)
7. The time of peak dose within 10,000 years after disposal is preferable for use in determining compliance with the IPS, as opposed to use of time to peak dose beyond 10,000 years, given the large differences in uncertainty of both...Further, it is questionable that requiring DOE to include in the EIS results from calculations to peak dose beyond 10,000 years would be an "indicator of the future performance of the disposal system" ...A better approach would be to test results from performance assessment calculations periodically with better data sets and simpler more understandable analyses that would serve both reality checks and confidence builders. (557)

Response To Issue B.1 through B.5:

For a variety of reasons, EPA agrees that a 10,000 year compliance period is meaningful, protective, practical to implement, and will encourage a robust repository that will provide long-term protection. Furthermore, DOE's calculation of peak dose after 10,000 years as a part of the environmental impact review process will make more complete information available in the public record, which we believe will have a positive effect on the Yucca Mountain repository program. We believe that the selection of a meaningful compliance period requires consideration of both technical and policy issues. We are aware that numerous estimates of projected doses from the proposed Yucca Mountain repository may reach their peak sometime after 10,000 years. We are sensitive to the recommendation of the NAS panel that, on the basis of technical considerations, the compliance period should be the time when the greatest risk occurs, within the limits of the long-term stability of the geologic environment. For Yucca Mountain, this could extend up to one million years.

While NAS suggested a compliance period that would extend to the time of peak risk, the panel also recognized that such a decision also has policy aspects not addressed by the NAS (NAS Report, p. 56). It suggested, for example, that "EPA might choose to establish consistent policies for managing risks from disposal of both long-lived hazardous nonradioactive materials and

radioactive materials.” With respect to the compliance period, EPA has used a 10,000-year limit in programs related to hazardous wastes. Waste subject to the land disposal restrictions requirements of the RCRA must meet a variety of requirements before land disposal is authorized. Facilities may seek an exemption from these requirements by demonstrating that there will be no migration of hazardous constituents from the disposal unit for as long as the waste remains hazardous (40 CFR 268.6). With respect to underground injection wells under the purview of the SDWA, we have specifically required a demonstration that the injected fluid will not migrate within 10,000 years [40 CFR 148.20(a)]. Finally, with respect to the WIPP no-migration petition, 10,000 years was judged the longest practical timeframe for evaluating this petition (55 *FR* 13068, 13073, April 6, 1990). More recently, modeling conducted in support of our HWIR has been carried out for 10,000 years (64 *FR* 63381, November 19, 1999). It is apparent that a compliance period of 10,000 years is the longest timeframe that has proved practical in our regulation of a variety of hazardous wastes.

EPA also evaluated the compliance period promulgated in EPA’s generally applicable environmental standards for the land disposal of SNF, HLW, and TRU wastes. The individual-protection and ground-water protection standards in 40 CFR part 191 (58 *FR* 66398, 66414, 66415, December 20, 1993) require a compliance period of 10,000 years. EPA is implementing this regulatory time period in the continuing certification process applicable to the WIPP in New Mexico (63 *FR* 27354, May 18, 1998). Notably, these 40 CFR part 191 standards apply to the same types of waste and type of disposal system (deep geologic repository) as proposed for Yucca Mountain. However, the WIPP LWA (Public Law 102-579) exempted Yucca Mountain from the 40 CFR part 191 standards and established a separate standards setting process detailed in the EnPA (Public Law 102-498), the authority for today’s rulemaking. Adopting a 10,000 year compliance period for Yucca Mountain would provide a consistent regulatory period for the land disposal of all SNF, HLW, and TRU waste in this country.

For extremely long time periods (up to a million years), EPA has significant concerns related to uncertainty in projecting human exposure. Over such long periods, we agree that it is possible to calculate the performance of the Yucca Mountain disposal system within certain bounds. Such a calculation, however, entails two aspects of uncertainty that may call into question the meaning of any projections of human health impact. One aspect of uncertainty relates to the **impact of long-term natural changes**. For extremely long time periods, major changes in the global climate could occur (see, for example, Chapter 7 of the BID). While the climate will remain, in general, similar to present day conditions over the next 10,000 years, over longer time frames comparable to the NAS suggested time of geologic stability, the global climate regime is virtually certain to pass through several glacial-interglacial cycles, with the majority of time spent in the glacial state (NAS Report, p. 91). These longer time periods would require the specification of exposure scenarios that would not be based upon current knowledge or cautious, but reasonable, assumptions, but rather upon potentially arbitrary assumptions. The NAS indicated that it knew of no scientific basis for identifying such scenarios (NAS Report, p. 96). As noted by the IAEA, beyond 10,000 years it may be possible to make general predictions about geological conditions but the range of possible biospheric conditions and human behavior is too wide to allow “reliable modeling” (IAEA TECDOC-767, 1994, Docket A-95-12, Item II-A-5).

The second aspect of uncertainty associated with extremely long time periods relates to the **possible biosphere conditions and human behavior**. Even for periods as “short” as 10,000 years, it is necessary to make certain assumptions. This time period is twice as long as recorded human history and represents a very long compliance period for current-day assessments. For periods on the order of one million years, even natural human evolutionary changes become a consideration, disregarding the recent advances in genetic engineering. Thus, reliable modeling of human exposure may be untenable and regulation to the time to peak dose, as suggested by the NAS, could become arbitrary.

For perspective, EPA looked at international repository programs. Many already invoke a 10,000 year compliance period. Canada, France, Germany, and Sweden have established 10,000 year compliance periods but have also committed to perform some kind of evaluation of the disposal system for time periods beyond 10,000 years (see the NAS Report, Table 2-3, p. 43, and GAO/RCED-94-172, “Nuclear Waste, Foreign Countries’ Approaches to High Level Waste Storage and Disposal,” August 1994, Docket A-95-12, Items II-A-1 and V-A-7).

Finally, a compliance period beyond 10,000 years would be unprecedented. Neither any of EPA’s national disposal programs nor international programs have implemented a compliance period approaching that suggested by the NAS panel (times approaching one million years). Given the unmanageable uncertainties associated with extreme compliance periods on the order of one million years, a more complicated licensing process would result with no additional discernable benefits. Focusing upon a 10,000-year compliance period forces more emphasis on those factors over which society can exert some degree of control, such as repository design features and engineered barriers. Over longer time frames, engineered barriers are more likely to have failed and protection of the environment depends more and more on the geological retardation in the movement of radionuclides away from the repository. By focusing upon an analysis of the features that society can influence or dictate at the site, it becomes more likely that the magnitude of the peak dose can be minimized even for periods beyond 10,000 years.

For the reasons cited above, EPA believes a 10,000 year compliance period is meaningful, practical to implement, and will result in a robust repository protective for time periods beyond 10,000 years. We have regulated hazardous wastes for as long as 10,000 years. Having a 10,000-year compliance period for Yucca Mountain ensures that SNF, HLW, and TRU wastes disposed anywhere in the United States will be held accountable to a 10,000 year compliance period. Imposing a compliance period beyond 10,000 years would be unprecedented both nationally and internationally and would carry with it significant and unmanageable uncertainties. This would likely complicate the licensing process so as to dilute the meaning of any associated licensing determinations. At the same time, making more complete information available on the impacts beyond 10,000 years as a part of the environmental impact review process provides an avenue for enhancing long-term repository performance. We believe this is the appropriate balance that allows for meaningful consideration of the issues related to both short term and long term aspects of repository development.

Response to Comment B.6:

The commenter is correct that EPA has not provided guidance on how the post-10,000 year modeling should be done. Although we have not specified detailed modeling approaches or modeling parameters for DOE to use, we have specified that the modeling should evaluate the peak dose to the RMEI (§ 197.35). As indicated in the DOE/VA (p. S-20, Docket A-95-12, Item V-A-5), the repository design is evolving, and will likely continue to do so during the licensing phase. We therefore thought it would be premature to specify how such modeling is to be done or how it is to be interpreted. Essentially, we expect DOE will model the same scenario it applies in assessing compliance with the IPS. The results will be published in the Yucca Mountain EIS and become part of the public record. As a result, more complete information will be available regarding the disposal system's projected performance in the post-10,000 year period. The NRC will determine how to evaluate the results of this long-term performance modeling as it relates to licensing. We do not intend NRC to use this modeling in assessing compliance with our standard; however, NRC is not prevented from doing so if it believes that modeling results beyond 10,000 years might provide insights to enhancements of the disposal system that would positively affect repository performance during or after the compliance period.

Response to Comment B.7:

This commenter suggests that requiring periodic updates of the performance assessment using more recent data would be more useful than modeling through the period of geologic stability, when uncertainties would render results “essentially meaningless.” This approach is somewhat similar to that taken for WIPP, where the WIPP LWA requires DOE to demonstrate compliance every five years. The EnPA, however, had no such mandate. EPA also supports the idea that alternative lines of reasoning, such as simpler and more understandable analyses, may be used to support the safety case for repository licensing. Whether these analyses would suffice for the licensing process is a matter for NRC to decide. It is noted that NRC's proposed 10 CFR part 63 does require a performance confirmation program to be carried out until permanent closure [proposed 10 CFR 63.102(m)]. This program would verify the assumptions, data, and analyses that support the performance assessment used to demonstrate compliance.